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Whiting Stocks and Their Gall-Bladder Parasites in British Waters

By Z. KABATA, D.Sc.
Marine Laboratory, Aberdeen
January, 1967

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Whiting Stocks and their Gall-Bladder Parasites in British Waters

INTRODUCTION

The value of parasites as biological tags for fish was discussed by the author on an earlier occasion (Kabata, 1963). On that occasion the importance of parasitological evidence for stock discrimination studies was illustrated by myxosporidian infections of the gall-bladder of whiting, *Merlangius merlangus* (L.). From the analysis of data collected during 1958-59 it was concluded that the whiting population of the North Sea can probably be divided into two stocks, inhabiting the areas north of 56°N and south of 54°N respectively, the intervening area between 54°N and 56°N constituting a 'mixing zone' for members of the two stocks.

The main physical feature of this zone is the Dogger Bank, stretching obliquely across it and acting, in some degree, as a geographical barrier. From the ecological point of view, the zone coincides with a definite biological discontinuity line, marked by differences in plankton indicator species (Russell, 1935, 1939).

The parasitological clue to the distinctness of the northern whiting stock was the predominance of the gall-bladder infection with *Ceratomyxa arcuata* Thelohan, 1892, while the southern stock was infected mainly with *Myxidium sphaericum* Thelohan, 1892 (defined here, in agreement with Noble (1957), as including *M. bergense* Auerbach, 1910). Intermediate levels of infection with both these species were found in the fish caught in the mixing zone.

It seemed desirable to check the results obtained from that work by repeating it over subsequent years, and to extend the examination of whiting gall-bladders to the populations occurring off the north and west coasts of the British Isles. The results of these further studies are presented in this paper.

MATERIALS AND METHODS

In all, 7,527 whiting were examined. The length, sex and age of each fish were recorded. The gall-bladders were removed and stored in individual tubes, usually preserved in 4% formalin made up with sea water, though alcohol was occasionally used as a preservative. Some examinations of the gall-bladders were carried out at sea, directly after their removal from the fish. Since, however, conditions for the microscopical examinations at sea proved rather unfavourable, most of the material was examined in the laboratory, with the minimum possible delay. A drop of the gall-bladder content and a smear from its wall were inspected at a magnification × 450 with the aid of phase contrast illumination.

For the purpose of this study, the region sampled was divided into areas, as shown in Figure 1. The areas A, B and C correspond to the northern, mixing and southern zones of the previous work (Kabata, 1963). In these three areas, the material on which the present report is based was collected from 1960 to 1964 inclusive. In the remaining areas D–H, the collections were made from 1958 to 1964 inclusive.

GENERAL COMMENTS ON GALL-BLADDER INFECTIONS

As far as is known, the myxosporidian parasites of the gall-bladders of fishes make their entry into the organ through the bile duct after being ingested by the host. The parasite reproduces within the infected organ, repeated reproductive cycles increasing the numbers of the parasites in it, until it becomes crowded with their successive generations. The spores produced during each cycle are partially and periodically evacuated with the bile by the contractions of the bladder, and are voided with the faeces into the sea. There they float and disperse, ready for infection of a suitable host. Since in the course of its reproductive cycle the parasite becomes temporarily attached to and affects the gall-bladder wall, in time the responsive reactions of the wall tissues produce hypertrophy, increased thickness and loss of contractility of the bladder. The gall-bladders

heavily infected with *Myxidium sphaericum* can usually be recognised with the naked eye, being enlarged, hard and pale, with a yellow tinge. The final outcome of the infection is, presumably, a complete functional elimination of the bladder. The author is inclined to believe that the infection persists in the fish for as long as the bladder is capable of supporting the life of the parasite population, a period almost certainly extending over several years.

The gall-bladders of whiting in the area studied are infected with the following myxosporidians: *Ceratomyxa arcuata* Thelohan, 1892, *Myxidium sphaericum* Thelohan, 1892, *Leptotheca informis* Auerbach, 1910, and *Zschokkella hildae* Auerbach, 1910. *Z. hildae* is rare and has no value as a biological tag. *L. informis*, although a very common gall-bladder parasite, occurs more or less uniformly over wide areas, its distribution pattern detracting from its indicative value. It appears, however, that its morphology is not entirely the same throughout the area. For example, in the southern part of the region examined, the spores of this species are definitely larger than those found in the north. The trophic stages in the north are commonly seen to have fairly long pseudopodia, which are very seldom observed in the south. A thorough systematic and morphological study of this species might, therefore, prove rewarding. As shown in the previous work, it is the first two species mentioned above which can best be used for stock discrimination studies.

Although most localities in the area sampled have two commonly-occurring myxosporidian gall-bladder parasites (*L. informis* and either *C. arcuata* or *M. sphaericum*), multiple infections are quite rare. Of the total number of fish examined in the course of this work, 5,777 (76%) were infected. Of these, 98·6% were infected with one species, 1·4% with two species and only 0·03% with three species of Myxosporidia. While the scarcity of the triple infections can be attributed to the fact that one of the three species is very rare in most areas considered, the scarcity of the two-species infection must be due to other reasons. It points, in fact, to the possibility of the existence of antagonistic relationships between the myxosporidian species. Such antagonism might either be direct or express itself in the conditioning of the infected environment by the first species, so as to make it difficult for the second species to become established.

To be useful as a biological tag, the infection must be both fairly high and persistent, without marked fluctuations throughout the life of the host population. As concluded in the previous paper (Kabata, 1963), the gall-bladder infections with Myxosporidia in whiting fulfil these conditions. The changes in the infection with the age of the host were re-examined for the area A (northern North Sea). The prevalence of infection in whiting of different age-groups in that area is shown in Table I.

TABLE I

AGE OF WHITING AND GALL-BLADDER INFECTIONS IN AREA A

Age	No. examined	*Ceratomyxa*		*Myxidium*		*Leptotheca*	
		No. inf.	%	No. inf.	%	No. inf.	%
0+	62	24	38·7	3	4·8	17	25·8
1+	859	392	45·6	11	1·3	270	31·4
2+	1,013	479	47·3	19	1·8	368	36·3
3+	536	225	42·0	10	1·9	225	42·0
4+	193	100	51·8	4	2·1	63	32.6
5+	54	34	63·0	1	1·8	14	25·9
older	51	28	54·9	2	3·9	16	31·4

The indicator species for area A, *C. arcuata*, occurs in about one in every three fish already at the age of 0+ and the infection level increases with age. By the time the fish reach the age of 5+, the parasite is found in almost two out of every three whiting in this area. As regards the occurrence of *M. sphaericum*, the species rare in the whiting of area A, there seems to be no rise in the level of infection with age. The parasite retains its incidental character throughout the life of the fish.

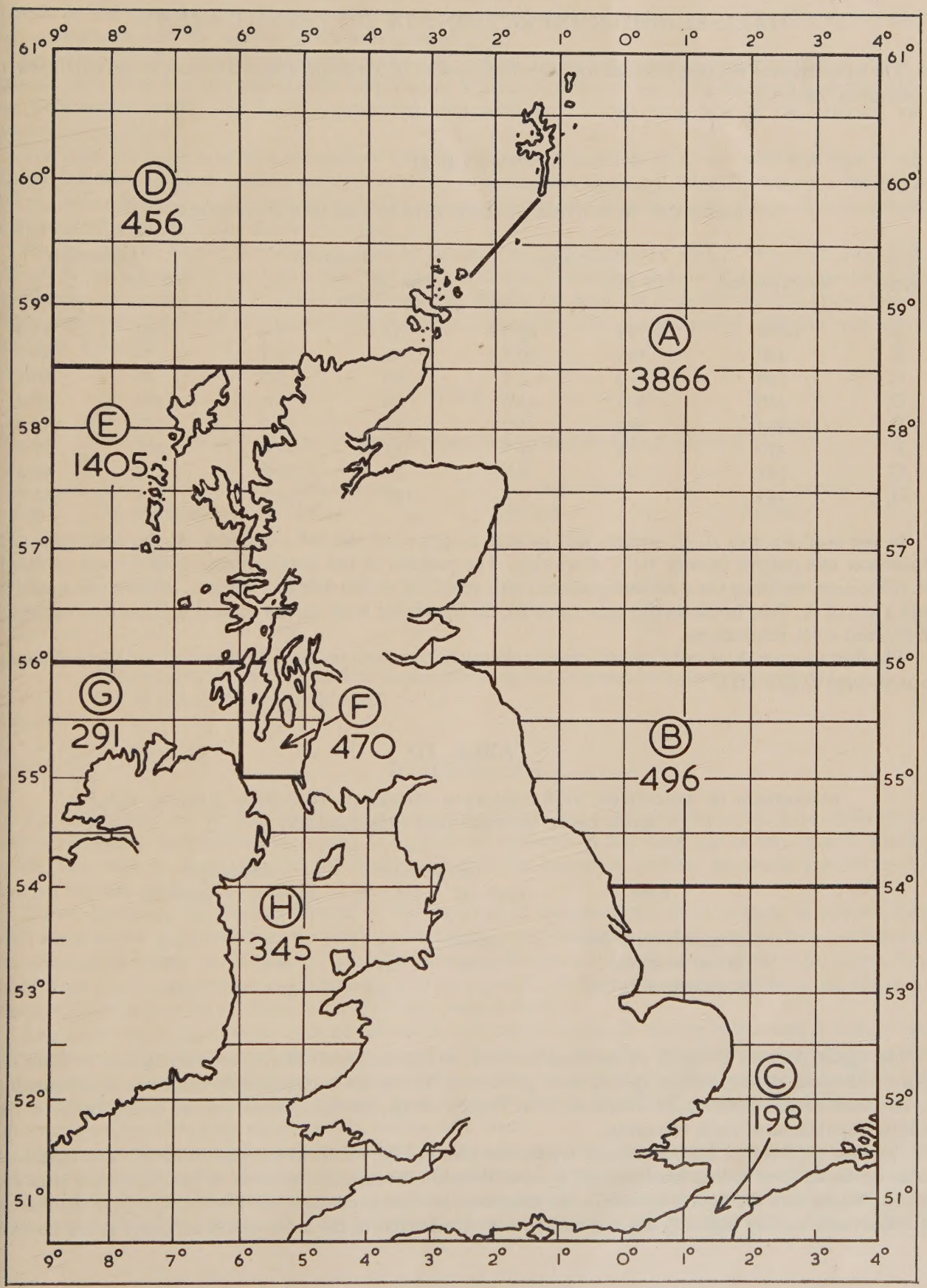

FIG. 1. Division of British waters into areas, coinciding with the distribution of the whiting stocks.

GALL-BLADDER INFECTIONS IN DIFFERENT AREAS

The proportion of whiting infected with the three species of Myxosporidia in different areas (see Figure 1) is shown in Table II.

TABLE II

PROPORTIONS OF WHITING INFECTED WITH SPECIES OF MYXOSPORIDIA

Area	No. examined	*Ceratomyxa* No. inf.	*Ceratomyxa* %	*Myxidium* No. inf.	*Myxidium* %	*Leptotheca* No. inf.	*Leptotheca* %
A	3,866	1,759	45·5	54	1.4	1,291	33·4
B	496	133	26·8	29	5·8	162	22·7
C	198	9	4·5	99	5·0	20	10·1
D	456	208	45·6	9	2·0	164	36·0
E	1,405	403	28·7	45	3·2	771	54·9
F	470	4	0·8	15	3·2	365	77·7
G	291	26	8·9	31	10·6	173	59·4
H	345	1	0·3	146	42·3	113	32·7

In the northern area A, *C. arcuata* was present in 45·5% of the fish examined. At the same time, *M. sphaericum* was present in only 1·4% of whiting. The position in the southern area (area C) was reversed, *M. sphaericum* assuming the dominant position, with 50·0% of all fish infected, while *C. arcuata* was found in only 4·5% of the fish. In the mixing zone (area B), the figures for both species showed intermediate values of 26·8% and 5·8% respectively.

The data for areas A, B and C show a close similarity between the results now discussed and those obtained in 1958-1959 (Table III).

TABLE III

COMPARISON OF INFECTIONS WITH INDICATOR SPECIES IN 1958–1959 (KABATA, 1963) WITH THOSE IN 1960–1964 (PERCENTAGES)

Area	*Ceratomyxa* 1958–59	*Ceratomyxa* 1960–64	*Myxidium* 1958–59	*Myxidium* 1960–64
A (north of 56°N)	46·0	45·5	1·3	1·4
B (56°N–54°N)	21·0	26·0	8·0	5·8
C (south of 54°N)	9·0	4·5	40·0	50·0

The figures for area D (north of Scotland and west of Shetland and Orkney) are very similar to those for area A. All three myxosporidian species were present in both areas in comparable numbers. Consequently, on the basis of the gall-bladder infections with Myxosporidia, no distinctions can be found between the whiting populations of these two areas.

The position is rather different in area E (the Minches and the waters to the west of them). The infections occurring in this area were at levels similar to those found in the intermediate zone of the North Sea (area B). By comparison with the figures in area D, the incidence of *Ceratomyxa* here was lower (28·7%), while that of *Myxidium* was slightly higher (3·2%). A feature not encountered in the areas described above is the marked

increase in the incidence of *Leptotheca*, which was here much more abundant than in the North Sea areas (54%, compared with the highest North Sea figure of 33%).

Area G covers the region to the north and west of Ireland, bordering on area E to the north and area F to the east. The feature of the gall-bladder infections of whiting in this area was the scarcity of both *Myxidium* and *Ceratomyxa* (10·6% and 8·9% respectively), combined with a high proportion of fish infected with *Leptotheca* (59·4%).

The Irish Sea is considered as the separate area H, which is characterised by a very 'southern' type of gall-bladder infection. While *Myxidium* occurred in 42·3% of whiting examined in this area, *Ceratomyxa* was almost absent, its incidence (0·3%) being represented by a single infected fish. The incidence of *Leptotheca* resembled in numbers that found in the North Sea areas.

Finally, area F (Clyde) was distinguished by an infection pattern unlike that in any other area. Both *Myxidium* and *Ceratomyxa* were here quite rare (3·2% and 0·8% respectively), while *Leptotheca* attained great prominence, occurring in 77·7% of all fish examined. Within the area, the localities situated closer inshore were completely devoid of all myxosporidians except *Leptotheca*. The distribution of infection with age is shown in Table IV.

TABLE IV

AGE AND GALL-BLADDER INFECTION OF WHITING IN AREA F (CLYDE)*

Age	No. examined	*Ceratomyxa*		*Myxidium*		*Leptotheca*	
		No. inf.	%	No. inf.	%	No. inf.	%
0+	38	—	—	—	—	34	89·5
1+	191	3	1·6	7	3·7	156	81·7
2+	58	1	1·7	3	5·2	46	79·3
3+	57	—	—	4	7·0	48	84·2

*The figures in this table are based on numbers of fish different from those in Table II. Not all fish in the area were aged.

DISCUSSION

The information on the gall-bladder infections in the North Sea whiting given in this paper fully corroborates the earlier findings (Kabata, 1963). It suggests the existence in the North Sea of two separate whiting stocks, each with its own dominant gall-bladder parasite; the boundary between the stocks appears to run through the area of the Dogger Bank.

Before discussing the results obtained by the sampling in the west coast areas, it must be stressed that, while the presence of differences in the pattern of the gall-bladder infections provides positive evidence between the stocks and suggests that they might be, to some extent, distinct, no definite conclusions can be drawn from the absence of such parasitological differences. It is quite possible to have two separate stocks of fish which are completely uniform from the point of view of their parasite fauna.

As stated earlier, there seems to be no difference between the stocks of whiting to the west of Orkney and Shetland (area D) and those inhabiting the northern North Sea (area A). Whether this uniformity results from extensive and frequent exchanges between the populations on both sides of the northern isles cannot be ascertained from the parasitological evidence. Some indications obtained from the return of the fish tagged in this region suggest that such exchanges do, in fact, take place.

There are, however, definite differences between the myxosporidian infections of fish in area D and those in the more southerly areas. The scarcity of both *Myxidium* and *Ceratomyxa*, coupled with the high incidence of *Leptotheca* in area G (north and west of Ireland), suggests the existence there of a whiting population fairly distinct from that in area D. This population extends northwards, where it meets and mixes with the

whiting from area D in the intervening area E (the Minches), which constitutes a 'mixing zone' similar to that found in the central North Sea.

The parasitological evidence also suggests that the stock of whiting in the Irish Sea (area H) constitutes a distinct population. The infection of the gall-bladder of this stock is characterised by a virtual absence of *Ceratomyxa*, a low incidence of *Leptotheca* and a dominance of *Myxidium*. Any large-scale incursions into the area from the stocks farther north would result in definite alteration in the pattern of incidence of the gall-bladder parasites. It is known from other sources (Garrod and Gambell, 1965) that the Irish Sea and Clyde whiting recruits may be largely drawn from a common spawning ground situated on the boundary between the areas F and G and close to the boundary of area H. These movements of the young fish occur, however, at the stage at which they are still incapable of becoming infected. Therefore, in view of the differences shown by this parasitological study, the movement of substantial numbers of adult whiting from areas to the north of the North Channel into the Irish Sea appears unlikely. However, a movement in the opposite direction cannot be dismissed. In particular, the gall-bladder infections of some whiting found in area G (off the north coast of Ireland) are identical with those in the Irish Sea.

The situation is somewhat similar in the Clyde (area F). As mentioned earlier, it is believed that the small whiting population of this area is derived mainly from the spawning ground near the boundary with area G. As in the Irish Sea stock, the fish arrive in the Clyde before their gall-bladders become infected. Older migrants are less frequent. This situation appears to be corroborated by the scarcity of the older age groups, as well as by the results of tagging experiments (Garrod and Gambell, 1965). When the fish move out of the Clyde to the spawning ground, they usually do not return to that area.

The parasitological evidence supports this possibility. The whiting population of the Clyde area is characterised by the presence of very abundant *Leptotheca*, obviously enzootic in the area. Most of the fish infected with the other two species of Myxosporidia are probably those older migrants, which picked up the infection outside the area.

ACKNOWLEDGMENTS

The author wishes to express his indebtedness to Mr B. B. Parrish and Mr J. Hislop of the Marine Laboratory, Aberdeen, for their useful comments on the manuscript of this paper. He is also grateful to all those members of the staff of this laboratory who assisted in collecting the gall-bladders. His thanks are also due to Mr P. Hillis, Department of Lands, Dublin, and to Mr D. W. R. Rout, Fisheries Laboratory, Lowestoft, who generously rendered him the same assistance.

SUMMARY

More than 7,000 whiting were examined for the infection of the gall-bladder with Myxosporidia. Of the four species present, one (*Zschokkella hildae*) is rare and cannot be used as a biological tag. Two species (*Ceratomyxa arcuata* and *Myxidium sphaericum*) are very useful as tags.

The distribution of the infections in British waters (divided for this purpose into areas A–H) agrees with the earlier finding that the whiting stocks in the North Sea consist of two distinct populations, northern and southern, meeting in the general area of the Dogger Bank. The northern population is continuous with the whiting stocks to the north of Scotland and the west of the northern isles. The whiting stocks to the west of the British Isles consist of two populations, northern and southern, the latter distributed over the area west and north of Ireland. The two stocks meet in the zone to the west of the Minches and in the Minches themselves. The Irish Sea has a separate whiting stock and a small population in the Clyde area can be distinguished from the others.

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